SCIENCE

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*THE EVOLUTION OF THE SCIENTIFIC INVESTIGATOR.**

AMONG the tendencies characteristic of the science of our day is one toward laying greater stress on questions of the beginning of things, and regarding a knowledge of the laws of development of any object of study as necessary to its complete understanding in the form in which we find it. It may be conceded that the principle here involved is as applicable in the broadest field of thought as in a special research into the properties of the minutest organism. It, therefore, seems meet that the comprehensive survey of the realm of knowledge on which we are about to enter should begin by seeking to bring to light those agencies which have brought about the remarkable development of that realm to which the world of to-day bears witness. The principle in question is recognized in the plan of our proceedings by providing for each great department of knowledge a review of its progress during the century that has elapsed since the great event which the scene around us is intended to commemorate. But such reviews do not make up that general survey of science at large which is necessary to the development of our theme, and which must include the action of causes that had their origin long before our time. The movement which culminated in making the nineteenth century ever memorable in history is the outcome of a long series of causes, acting through many centuries, which are worthy

* Opening address of the president of the International Congress of Arts and Science, at the St. Louis Exposition, September 19, 1904.

of being brought into especial prominence on such an occasion as this. In setting them forth we should avoid laying stress on those visible manifestations which, striking the eye of every beholder, are in no danger of being overlooked, and search rather for those agencies whose activities underlie the whole visible scene, but which are liable to be blotted out of sight by the very brilliancy of the results to which they have given rise. It is easy to draw attention to the wonderful qualities of the oak; but, from that very fact, it may be needful to point out that the real wonder lies concealed in the acorn from which it grew.

Our inquiry into the logical order of the causes which have made our civilization what it is to-day will be facilitated by bringing to mind certain elementary considerations—ideas so familiar that setting them forth may seem like citing a body of truisms—and yet so frequently overlooked not only individually, but in their relation to each other, that the conclusion to which they lead may be lost to sight. One of these propositions is that psychical rather than material causes are those which we should regard as fundamental in directing the development of the social organism. The human intellect is the really active agent in every branch of endeavor—the *primum mobile* of civilization—and all those material manifestations to which our attention is so often directed are to be regarded as secondary to this first agency. If it be true that 'in the world is nothing great but man; in man is nothing great but mind,' then should the keynote of our discourse be the recognition at every step of this first and greatest of powers.

Another well-known fact is that those applications of the forces of nature to the promotion of human welfare which have made our age what it is are of such comparatively recent origin that we need go back only a single century to antedate their most important features, and scarcely more than four centuries to find their beginning. It follows that the subject of our inquiry should be the commencement, not many centuries ago, of a certain new form of intellectual activity.

Having gained this point of view our next inquiry will be into the nature of that activity, and its relation to the stages of progress which preceded and followed its beginning. The superficial observer, who sees the oak but forgets the acorn, might tell us that the special qualities which have produced such great results are expert scientific knowledge and rare ingenuity, directed to the application of the powers of steam and electricity. From this point of view the great inventors and the great captains of industry were the first agents in bringing about the modern era. But the more careful inquirer will see that the work of these men was possible only through a knowledge of laws of nature which had been gained by men whose work took precedence of theirs in logical order, and that success in invention has been measured by completeness in such knowledge. While giving all due honor to the great inventors, let us remember that the first place is that of the great investigators whose forceful intellects opened the way to secrets previously hidden from men. Let it be an honor and not a reproach to these men that they were not actuated by the love of gain, and did not keep utilitarian ends in view in the pursuit of their researches. If it seems that in neglecting such ends they were leaving undone the most important part of their work, let us remember that nature turns a forbidding face to those who pay her court with the hope of gain, and is responsive only to those suitors whose love for her is pure and undefiled. Not only is the special genius required in the investigator not that generally best adapted to applying the discov-

eries which he makes, but the result of his having sordid ends in view would be to narrow the field of his efforts, and exercise a depressing effect upon his activities. It is impossible to know what application knowledge may have until after it is acquired, and the seeker after purely useful knowledge will fail to acquire any real knowledge whatever.

We have here the explanation of the well-known fact that the functions of the investigator of the laws of nature, and of the inventor who applies these laws to utilitarian purposes are rarely united in the same person. If the one conspicuous exception which the past century presents to this rule is not unique, we should probably have to go back to Watt to find another. The true man of science of to-day and of all past time has no such expression in his vocabulary as useful knowledge. His domain is the whole of nature, and were he to attempt its division into the useful and the useless, he would drop from his high estate.

It is, therefore, clear that the primary agent in the movement which has elevated man to the masterful position he now occupies is the scientific investigator. He it is whose work has deprived plague and pestilence of their terrors, alleviated human suffering, girdled the earth with the electric wire, bound the continent with the iron way, and made neighbors of the most distant nations. As the first agent which has made possible this meeting of his representatives, let his evolution be this day our worthy theme.

It has been said that the scientific investigator is a new species of the human race. If this designation is applicable to a class defined only by its functions, then it is eminently appropriate. But the biologist may object to it on the ground that a species, or even a variety, is the product of heredity, and propagates only or mainly its own kind. The evolutionist may join hands with him on the ground that only new faculties, not new modes of activity, are to be regarded as products of evolution, but let us not stop to dispute about words. We have no need of the term 'species' in our present course of thought; but to deny the term evolution to the genesis of previously non-existent forms of intellectual activity is to narrow our conception of the course of nature, and draw a line of demarkation where no tangible boundary exists.

I am the more ready to invite your attention to the evolution of the scientific investigator, not only because the subject is closely correlated with human evolution in general, but because it is one branch of evolution which seems to me not to have received due prominence in discussions of the subject.

In our time we think of the process of development in nature as one going continuously forward through the combination of the opposite processes of evolution and dissolution. The tendency of our thought has been in the direction of banishing cataclysms to the theological limbo, and viewing nature as a sleepless plodder, endowed with infinite patience, waiting through long ages for results. I do not contest the truth of the principle of continuity on which this view is based. But it fails to make known to us the whole truth. The building of a ship from the time that her keel is laid until she is making her way across the ocean is a slow and gradual process; yet there is a cataclysmic epoch in her history, opening up a new era in her existence. It is the moment when, after lying for months or years a dead, inert, immovable mass, she is suddenly endowed with the power of motion and, as if imbued with life, glides into the stream, soon to begin a career of restless activity, of which the only bounds are those of the

ocean. I think it is thus in the development of humanity. Long ages may pass during which a race, to all external observations, appears to be making no real progress. Additions may be made to learning, and the records of history may constantly grow, but there is nothing in its sphere of thought or in the features of its life that can be called radically new. Yet, nature may have been all along slowly working in a way which evades our scrutiny until the result of her operations suddenly appears in a new and revolutionary movement, carrying the race to a higher plane of civilization.

It is not difficult to point out such epochs in human progress. The greatest of all, because it was the first, is one of which we find no record either in written or geological history. It was the epoch when our progenitors first took conscious thought of the morrow, first used the crude weapons which nature had placed within their reach to kill their prey, first built a fire to warm their bodies and cook their food. I love to fancy that there was some one first man, the Adam of evolution, who did all this, and who used the power thus acquired to show his fellows how they might profit by his example. When the members of the tribe or community which he gathered around him began to conceive of life as a whole—to include yesterday, to-day and to-morrow in the same mental grasp—to think how they might apply the gifts of nature to their own uses—a movement was begun which should ultimately lead to civilization.

Many, indeed, must have been the ages required for the development of this rudest primitive community into the civilization revealed to us by the most ancient tablets of Egypt and Assyria. After spoken language was developed, and after the rude representation of ideas by visible marks drawn to resemble them had long been practised, some real Cadmus must have invented an alphabet. When the use of a written language was thus introduced, the word of command ceased to be confined to the range of the human voice, and it became possible for master minds to extend their influence as far as a written message could be carried. Then were communities gathered into provinces, provinces into kingdoms, and kingdoms into the great empires of antiquity. Then arose a stage of civilization which we find pictured in the most ancient records—a stage in which men were governed by laws that were perhaps as wisely adapted to their conditions as our laws are to ours—in which the phenomena of nature were rudely observed, and striking occurrences in the earth or in the heavens recorded in the annals of the nation.

Vast was the progress of knowledge during the interval between these empires and the century preceding that in which modern science began. Yet, if I am right in making a distinction between the slow and regular steps of progress, each growing naturally out of that which preceded it, and the entrance of the mind at some fairly definite epoch into an entirely new sphere of activity, it would appear that there was only one such epoch during the entire interval. This was when abstract geometrical reasoning commenced, and astronomical observations aiming at precision were recorded, compared and discussed. Closely associated with it must have been the construction of the forms of logic. The radical difference between the demonstration of a theorem of geometry and the reasoning of every-day life, which the masses of men must have used from the beginning, and which few even to-day ever get beyond, is so evident at a glance that I need not dwell upon it. The principal feature of this advance is that by one of those antinomies of the human intellect of which examples are not wanting even in our own

time, the development of abstract ideas among the Greeks preceded the concrete knowledge of natural phenomena. When we reflect that in the geometry of Euclid the science of space was brought to such logical perfection that even to-day its teachers are not agreed as to the practicability of any radical improvement upon it, we can not avoid the feeling that a very slight change in the direction of the intellectual activity of these people would have led to the beginning of natural science. But it would seem that the very purity and perfection which was aimed at in their system of geometry stood in the way of any extension or application of its methods and spirit to the field of nature. One example of this is worthy of attention. In modern teaching the idea of magnitude as generated by motion is freely introduced. A line is described by a moving point; a plane by a moving line; a solid by a moving plane. It may, at first sight, seem singular that this conception finds no place in the Euclidian system. But we may regard the omission as a mark of logical purity and rigor. Had the real or supposed advantages of introducing motion into geometrical conceptions been suggested to Euclid, we may suppose him to have replied that the theorems of space are independent of time; that the idea of motion necessarily implies time, and that, in consequence, to avail ourselves of it would be to introduce an extraneous element into geometry. The result was that, in keeping this science pure from ideas which did not belong to it, it failed to form what might otherwise have been the basis of physical science. Its founders missed the discovery that the methods of geometric demonstration could be extended into other and wider fields than that of space. Thus not only the development of applied geometry, but the reduction of other conceptions to a rigorous mathematical form was indefinitely postponed.

The idea of continuous increase in time is that by which the conceptions of the infinitesimal calculus can most easily find root in the mind of the beginner. It is quite possible that the contempt of the ancient philosophers for the practical application of their science, which has continued in some form to our own time, and which is not altogether unwholesome, was a powerful factor in preventing the development of this idea.

Astronomy is necessarily a science of observation pure and simple, in which experiment can have no place except as an auxiliary. The vague accounts of striking celestial phenomena, handed down by the priests and astrologers of antiquity, were followed in the times of the Greeks by observations having, in form at least, a rude approach to precision, though nothing like the degree of precision that the astronomer of to-day would reach with the naked eye, aided by such rude instruments as he could fashion from the tools at command of the ancients.

The rude observations commenced by the Babylonians were continued with gradually improving instruments, first by the Greeks and then by the Arabians; but the results failed to afford any insight into the true relation of the earth to the heavens. What was most remarkable in this failure is that to take a first step forward, which would have led on to success, no more was necessary than a course of abstract thinking vastly easier than that required for working out the problems of geometry. That space is infinite is an unexpressed axiom, tacitly assumed by Euclid and his successors. Combining this with the most elementary consideration of the properties of the triangle, it would be seen that a given body of any size could be placed at such a distance in space as to appear to us like a

point. Hence a body as large as our earth, which was known to be a globe from the time that the ancient Phœnicians navigated the Mediterranean, if placed in the heavens at a sufficient distance, would look like a star. The obvious conclusion thai the stars might be bodies like our globe, shining either by their own light or by that of the sun, would have been a first step to an understanding of the true system of the world.

There is historic evidence that this deduction did not wholly escape the Greek thinkers. It is true that the critical student will assign little weight to the current belief that the vague theory of Pythagoras that fire was at the center of all things, implies a conception of the heliocentric theory of the solar system. But the testimony of Archimedes, confused though it is in form, leaves no serious doubt that Aristarchus of Samos not only propounded the view that the earth revolves both on its own axis and around the sun, but that he correctly removed the great stumbling-block in the way of this theory by adding that the distance of the fixed stars was infinitely greater than the dimensions of the earth's orbit. Even the world of philosophy was not yet ready for this conception, and so far from seeing the reasonableness of the explanation, we find Ptolemy arguing against the rotation of the earth on grounds which careful observations of the phenomena around him would have shown to be ill founded.

Physical science, if we can apply that term to an uncoordinated body of facts, was successfully cultivated from the earliest times. Something must have been known of the properties of metals, and the art of extracting them from their ores must have been practised from the time that coins and medals were first stamped. The properties of the most common chemical compounds were discovered by alchemists in their vain search for the philosopher's stone, but no actual progress worthy of the name rewarded the practitioners of the black art.

Perhaps the first approach to a correct method was that of Archimedes who, after careful thinking, worked out the law of the lever, reached the conception of the center of gravity, and demonstrated the first principles of hydrostatics. It is, therefore, all the more remarkable that he did not extend his researches into the phenomena of motion, whether spontaneous or produced by force. The stationary condition of the human intellect was most strikingly illustrated by the fact that not until the time of Leonardo was any substantial advance made on his discovery. To sum up in one sentence the most characteristic feature of ancient and medieval science, we see a notable contrast between the precision of thought implied in the construction and demonstration of geometrical theorems and the vague, indistinct character of the ideas of natural phenomena generally, a contrast which did not disappear until the foundations of modern science began to be laid.

We should miss the most essential point of the difference between medieval and modern learning if we looked upon it as mainly a difference either in the precision or the amount of knowledge. The development of both of these qualities would, under any circumstances, have been slow and gradual, but sure. We can hardly suppose that any one generation, or even any one century, would have seen the complete substitution of exact for inexact ideas. Slowness of growth is as inevitable in the case of knowledge as in that of a growing organism. The most essential point of difference is one of those seemingly slight ones, the importance of which we are too apt to overlook. It was like the drop of blood in the wrong place, which some one has told us makes all the difference between

a philosopher and a maniac. It was the difference between a live tree and a dead one; between an inert mass and a growing organism. The transition of knowledge from the dead to the living form must, in any complete review of the subject, be looked upon as the really great event of modern times. Before this event the intellect was bound down by a scholasticism which regarded knowledge as a rounded whole, the parts of which were written in books and carried in the minds of men. The student was taught from the beginning of his work to look upon authority as the foundation of his beliefs. The older the authority, the greater the weight it carried. So effective was this teaching that it seemed never to have occurred to individual men that they had every opportunity enjoyed by Aristotle of discovering truth, with the added advantages of all his knowledge to begin with. With all the development of formal logic, that practical logic which could see that the last of a series of authorities, every one of which rested on those which preceded it, could never form a surer foundation for any doctrine than that supplied by its original propounder. The result of this view of knowledge was that, although during the fifteen centuries following the death of the geometer of Syracuse, great universities were founded at which generations of professors expounded all the learning of their time, neither professor nor student ever suspected what latent possibilities of good were concealed in the most familiar operations of nature. Every one felt the wind blow, saw water boil and heard the thunder crash, but never thought of investigating the forces here at play. Up to the middle of the fifteenth century the most acute observer could scarcely have seen the dawn of a new era.

In view of this state of things it must be regarded as one of the most remarkable facts in evolutionary history that four or five men, whose mental constitution was either typical of the new order of things or who were powerful agents in bringing it about, were all born during the fifteenth century—four of them at least at so nearly the same time as to be contemporaries.

Leonardo da Vinci, whose artistic genius has charmed succeeding generations, was also the first practical engineer of his time, and the first man after Archimedes to make a substantial advance in developing the laws of motion. That the world was not prepared to make use of his scientific discoveries does not detract from the significance which must attach to the period of his birth.

Shortly after him was born the great navigator whose bold spirit was to make known a new world, thus giving to commercial enterprise that impetus which was so powerful an agent in bringing about a revolution in the thoughts of men.

The birth of Leonardo was shortly followed by that of Copernicus, the first after Aristarchus to demonstrate the true system of the world. In him more than in any of his contemporaries do we see the struggle between the old modes of thought and the new. It seems also pathetic and is certainly most suggestive of the general view of knowledge taken at this time that, instead of claiming credit for bringing to light great truths before unknown, he made a labored attempt to show that, after all, there was nothing really new in his system, which he claimed to date from Pythagoras and Philolaus. In this connection it is curious that he makes no mention of Aristarchus who, I think, will be regarded by conservative historians as his only demonstrated predecessor. To the hold of the older ideas upon his mind we must attribute the fact that in constructing his system he took great pains to make as little change as possible in ancient conceptions.

Luther, the greatest thought-stirrer of them all, practically of the same generation with Copernicus, Leonardo and Columbus, does not come in as a scientific investigator, but as the great loosener of chains which had so fettered the intellects of men that they dared not think otherwise than as the authorities had thought. Later in the same century was born Paracelsus, in whose checkered life we see, as in the case of Copernicus, the struggle between the old modes of thought and the new.

Almost coeval with the advent of those intellects was the discovery of the art of printing with movable type. Gutenberg was born during the first decade of the century, and his associates and others credited with the invention not many years afterward. If we accept the principle on which I am basing my argument, that we should assign the first place to the birth of those psychic agencies which started men on new lines of thought, then surely was the fifteenth the wonderful century!

Let us not forget that, in assigning the actors then born to their places, we are not recounting history, but studying a special phase of evolution. It matters not for us that no university invited Leonardo to its halls, and that his science was valued by his contemporaries only as an adjunct to the art of engineering. The great fact still is that he was the first of mankind to propound laws of motion. It is not for anything in Luther's doctrines that he finds a place in our scheme. No matter for us whether they were true or false. What he did toward the evolution of the scientific investigator was to show by his example that a man might question the best established and most venerable authority and still live—still preserve his intellectual integrity—still command a hearing from nations and their rulers. It matters not for us whether Columbus ever knew that he had discovered a new continent. His work was to teach that neither hydra, chimera nor abyss—neither divine injunction nor infernal machination—was in the way of men visiting every part of the globe, and that the problem of conquering the world reduced itself to one of sails and rigging—hull and compass. The better part of Copernicus was to direct man to a view point whence he should see that the heavens were of like matter with the earth. All this done, the acorn was planted from which the oak of our civilization should spring. The mad quest for gold which followed the discovery of Columbus—the questionings which absorbed the attention of the learned—the indignation excited by the seeming vagaries of a Paracelsus, the fear and trembling lest the strange doctrine of Copernicus should undermine the faith of centuries—were all helps to the germination of the seed—stimuli to thought which urged it on to explore the new fields opened up to its occupation. This given, all that has since followed came out in the regular order of development, and need be here considered only in those phases having a special relation to the purpose of the present assembly.

So slow was the growth at first that the sixteenth century may scarcely have recognized the inauguration of a new era. Torricelli and Benedetti were of the third generation after Leonardo; and Galileo, the first to make a substantial advance upon his theory, was born more than a century after him. Only two or three men appeared in a generation who, working alone, could make real progress in discovery, and even these could do little in leavening the minds of their fellowmen with the new ideas. Up to the middle of the seventeenth century an agent which all our experience since that time shows to be necessary to the most productive intellectual activity was wanting. This was the attrition of like minds, making suggestions to each

other, criticising, comparing and reasoning. This element was introduced by the organization of the Royal Society of London and the Academy of Sciences of Paris. The members of these two bodies seem like ingenious youths suddenly thrown into a new world of interesting objects, the purposes and relations of which they had to discover for themselves. The novelty of the situation is strikingly shown in the questions which occupied the minds of the incipient investigators. One natural result of British maritime supremacy was that the aspirations of the fellows of the Royal Society were not confined to any continent or hemisphere. Inquiries were sent all the way to Batavia to know 'whether there be a hill in Sumatra which burneth continually, and a fountain which runneth pure balsam.' The astronomical precision with which it seemed possible that physiological operations might go on was evinced by the inquiry whether the Indians can so prepare that stupefying herb datura that 'they make it lie several days, months, years according as they will, in a man's body without doing him any harm, and at the end kill him without missing an hour's time.' Of this continent one of the inquiries was whether there be a tree in Mexico that yields water, wine, vinegar, milk, honey, wax, thread and needles.

Among the problems before the Paris Academy of Sciences those of physiology and biology took a prominent place. The distillation of compounds had long been practised, and the fact that the more spirituous elements of certain substances were thus separated naturally led to the question whether the essential essences of life might not be discoverable in the same way. In order that all might participate in the experiments, they were conducted in the full session of the academy, thus guarding against the danger of any one member obtaining for his exclusive personal use a possible elixir of life. Cats, dogs, birds of various species, a wide range of the animal and vegetable kingdom, in fact, were thus analyzed. The practise of dissection was introduced on a large scale. That of the cadaver of an elephant occupied several sessions, and was of such interest that the monarch himself was a spectator.

To the same epoch with the formation and first work of these two bodies belongs the invention of a mathematical method which in its importance to the advance of exact science may be classed with the invention of the alphabet in its relation to the progress of society at large. The use of algebraic symbols to represent quantities had its origin before the commencement of the new era, and gradually grew into a highly developed form during the first two centuries of that era. But this method could represent quantities only as fixed. It is true that the elasticity inherent in the use of such symbols permitted of their being applied to any and every quantity; yet, in any one application, the quantity was considered as fixed and definite. But most of the magnitudes of nature are in a state of continual variation; indeed, since all motion is variation, the latter is a universal characteristic of all phenomena. No serious advance could be made in the application of the algebraic method to the expression of physical phenomena until the language of that method could be so extended as to express variation in quantities, as well as the quantities themselves. This extension, worked out independently by Newton and Leibnitz, must be classed among the greatest epoch-making conceptions in exact science. With it the way was opened for the unimpeded and continually accelerated progress of the last two centuries. The feature of this period which has the closest relation to the purpose of our coming together is the seemingly unending subdivision of knowledge

into specialties, many of which are becoming so minute and so isolated that they seem to have no interest to any but their few pursuers. Happily, science itself has afforded a corrective for its own tendency in this direction. The careful thinker will see that in these seemingly diverging branches common elements and common principles are coming more and more to light. There is an increasing recognition of methods of research and of deduction which are common to large branches or to the whole of science. We are more and more recognizing the principle that progress in knowledge implies its reduction to a more exact form, and the expression of its ideas in language more or less mathematical. The problem before the organizers of this congress was, therefore, to bring the sciences together, and seek for the unity which we believe underlies their infinite diversity. The assembling of such a body as now fills this hall was scarcely possible in any preceding generation, and is made possible now only through the agency of science itself. It differs from all preceding international meetings by the universality of its scope, which aims to include the whole of knowledge. It is also unique in that none but leaders have been sought out as members. It is unique in that so many lands have delegated their choicest intellects to carry on its work. They come from the country to which our republic is indebted for a third of its territory, including the ground on which we stand; from the land which has taught us that the most scholarly devotion to the languages and learning of the cloistered past is compatible with leadership in the practicable application of modern science to the arts of life; from the island whose language and literature have found a new field and a vigorous growth in this region; from the last seat of the holy Roman Empire; from the country which, boasting of the only monarch that ever made an astronomical observation at the Greenwich Observatory, has enthroned science in one of the highest places in its government; from the peninsula so learned that we have invited one of its scholars to come here and teach us our own language; from the land which gave birth to Leonardo, Galileo, Torricelli, Columbus, Volta—what an array of immortal names!—from the little republic of glorious history which, breeding men rugged as its eternal snow-peaks, has yet been the seat of scientific investigation since the day of the Bernoullis; from the land whose heroic dwellers did not hesitate to use the ocean itself to protect it against invaders, and which now makes us marvel at the amount of erudition compressed within its little area; from the nation of the farthest east, which, by half a century of unequaled progress in the arts of life, has made an important contribution to evolutionary science through demonstrating the falsity of the theory that the most ancient races are doomed to be left in the rear of the advancing age—in a word, from every great center of intellectual activity on the globe I see before me eminent representatives of that world-advance which we have come to celebrate.

Gentlemen and scholars all! You do not visit our shores to find great collections in which long centuries of humanity have given expression on canvas and in marble to their hopes, fears and aspirations. Nor do you expect institutions and buildings hoary with age. But as you feel the vigor latent in the fresh air of these expansive prairies, which has collected the products of human genius by which we are here surrounded and, I may add, brought us together—as you study the institutions which we have founded for the benefit not only of our own people but of humanity at large; as you meet the men who, in the short space of one century, have transformed this val-

ley from a savage wilderness into what it is to-day—then may you find compensation for the want of a past like yours by seeing with prophetic eye a future world power of which this region shall be the seat. If such is to be the outcome of the institutions which we are now building up, then may your present visit be a blessing both to your posterity and ours, by making that power one for good to all mankind. Your deliberation will help to demonstrate to us and to the world at large that the reign of law must supplant that of brute force in the relations of the nations, just as it has supplanted it in the relations of individuals. You will help to show that the war which science is now waging against the sources of disease, pain and misery offers an even nobler field for the exercise of heroic qualities than can that of battle. We hope that when, after your all too fleeting sojourn in our midst, you return to your own shores, you will long feel the influence of the new air you have breathed in an infusion of increased vigor in pursuing your varied labors. And if a new impetus is thus given to the great intellectual movement of the past century, resulting not only in promoting the unification of knowledge, but in widening its field through new combinations of effort on the part of its votaries, the projectors, organizers and supporters of this Congress of Arts and Science will be justified of their labors.

Simon Newcomb.

THE EVIDENCE OF EVOLUTION.*

Mr. President, Members of the University of Chicago, Ladies and Gentlemen:

The noble aim of university teaching is the lifting up of mankind to a higher appreciation of the ideas of life and truth. It has to cultivate the most intimate connection between theory and practise, between abstract science and actual life. Throughout the world of research this connection is felt to be the real stimulus of the work, the very basis of its existence. American universities and American science have developed themselves on this leading principle, and it is especially on this account that high admiration is given them by their European sisters. Nowhere in this world is the mutual concourse between practise and science so general as here, and nowhere is the influence of the universities so widely felt as in this country. Perfect freedom of thought and investigation, unhampered rights of professing and defending one's conviction, even if it should be wholly contrary to the universal belief, are the high privileges of all real universities. Wealthy citizens spend their possessions in the founding of such institutions, convinced that this is the best way of promoting public welfare. The government liberally supplies funds for scientific research, whenever its application to practical business is clear. Your system of promoting agriculture by means of experiment stations, of scientifically conducted farm-cultures, of inquiries in all parts of the world, and of collecting, introducing and trying all kinds of plants that might become useful crops, is not only admired, but even highly envied by us Europeans.

It is not without hesitation that I have accepted the honorable invitation to speak before this renowned center of learning. The ideas to which I have been conducted by my experiments are to a large degree different from current scientific belief. But I have trusted to your willingness to listen to new facts and divergent convictions, and to your readiness to acknowledge whatever spark of truth might be found in them. Unbiased by prejudice, the calm air of the university and the enthusiasm of

* Convocation address, University of Chicago, September 2, 1904.

youth seeking only truth and convinced that only pure truth can bring real progress are the judges to which I gladly submit my conceptions.

My ideas have grown slowly, and have only reached their definiteness and full development under the protection of the high principles of university freedom. I have needed nearly twenty years to develop them and to gather the evidence by means of which I hope to convince you. I kept my secret until some years ago, and worked only for myself. In this respect old universities, as ours are in Europe, have a distinct advantage over your young American institutions. With you all is sparkling and boiling, with us it is the quietness of solitude, even in the midst of a busy city. But your students and teachers are expected to show what they are doing, and to produce their results at short intervals. In Europe, on the contrary, we are trusted and left free even on this point. Hardly anybody has ever asked me what I was doing, and even those who from time to time visited my garden were content with what I could show them, without telling my real difficulties and my real hopes.

To my mind, this is a high privilege. The solution of the most intricate problems often does not require vast laboratory equipment, but it always requires patience and perseverance. Patience and perseverance in their turn require freedom from all pressure, and especially from the need of publishing early and often unripe results. Even now I would prefer to spend this hour in recounting the obligations which the doctrine of evolution is under to such men as Lamarck and Darwin. I should like to point out how they have freed inquiry from prejudice and drawn the limits between religion and science; how they have caused the principle of evolution to be the ruling idea in the whole dominion of the study of the organic world, and how this idea has been suggestive and successful, comprehensive and hopeful during a whole century of continuous research. Everywhere it is recognized to take the leadership. It has been the means of innumerable discoveries, and whole sciences have been started from it. Embryology and ontogeny, phylogeny and the new conceptions of taxonomy, paleontology of plants and of animals, sociology, history and medicine, and even the life history of the earth on which we live, are in reality in their present form the products of the idea of evolution.

Instead of telling you of my own work, I should like to sketch the part which of late the scientists of the United States have taken in this work. Mainly in two lines a rapid advancement has been inaugurated in this country. I refer to the pure university studies and the work of the agricultural stations. Highly valuable is the application of science to agriculture in the improvement of races. Each of you knows how this artificial production of races of animals and plants was one of the great sources of evidence on which Darwin founded his theory. But at his time the available evidence was only very scanty when we compare it with the numerous facts and the improved methods which now are the result of half a century's additional work. America and Europe have combined in this line, and the vast amount of facts, heaped up by numerous investigators and numerous well-equipped institutions, has produced quite a new basis for a critical review of Darwin's theory.

I have tried to combine all these too dispersed facts and to bring them together, in order to obtain a fuller proof for the main points of Darwin's conception. In one subordinate point my results have been different from those of Darwin, and it is this point which I have been invited by the

kindness of your president to discuss before you.

Darwin's theory is commonly indicated as the theory of natural selection. This theory is not the theory of descent. The idea of descent with modification, which now is the basis of all evolutionary science, is quite independent of the question how in the single instances the change of one species into another has actually taken place. The theory of descent remains unshaken even if our conception concerning the mode of descent should prove to be in need of revision.

Such a revision seems now to be unavoidable. In Darwin's time little was known concerning the process of variability. It was impossible to make the necessary distinctions. His genius recognized two contrasting elements; one of them he called sports, since they came rarely, unexpectedly and suddenly; the other he designated as individual differences, conveying thereby the notion of their presence in all individuals and at all times, but in variable degrees.

Sports are accidental changes, resulting from unknown causes. In agricultural and horticultural practise they play a large part, and whenever they occur in a useful direction, they are singled out by breeders and become the sources of new races and new varieties. Individual differences are always present, no two persons being exactly alike. In the same way the shepherd recognizes all his sheep by distinct marks, and to find two ears in a field of wheat which can not be distinguished from one another by some peculiarity is a proposition which everybody knows to be impossible. Many highly improved races of forage plants and agricultural crops have been produced by intelligent breeders simply on the ground of these always available dissimilarities. They can be selected and accumulated, augmented and heaped up, until the new race is distinctly preferable to the original strain.

In ordinary agricultural breeding, however, it is very difficult to distinguish sharply between these two principles. Moreover, for practical purposes, this distinction has no definite use. The practise of selection is nearly the same in both cases, and, besides hybridizing, with which we are not now concerned, selection is as yet practically the only means for the breeder to improve his races. Hence it came that at Darwin's time there was no clear distinction between the two types of variations, at least not to such an extent that a theory of the origin of species could confidently rely upon it.

Quetelet's celebrated law of variability was published only some years after the appearance of Darwin's 'Origin of Species.' Variability seemed until then to be free from laws, and nearly everything could be ascribed to it or explained by it. But the renowned Belgian scientist showed that it obeys laws exactly in the same way as the remainder of the phenomena of nature. The law which rules it is the law of probability, and according to this law the occurrence of variations, their frequency and their degree of deviation can be calculated and predicted with the same certainty as the chance of death, of murders, of fires and of all those broad phenomena with which the science of sociology and the practise of insurance are concerned.

The calculations of probable variations based on this most important law did not, however, respond to the demands of evolution. Specific characters are usually sharply defined against one another. They are new and separate units more often than different degrees of the same qualities. Only with such, however, Quetelet's law is concerned. It explains the degrees, but not the origin, of new peculiarities. Moreover, the degrees of deviation are subject

to reversion to mediocrity, always more or less returning in the progeny to the previous state. Species, on the contrary, are usually constant and do not commonly or readily revert into one another. It is assumed that from time to time specific reversions occur, but they are too rare to be comparable with the phenomena which are ruled by the law of probability.

A thorough study of Quetelet's law would no doubt at once have revealed the weak point in Darwin's conception of the process of evolution. But it was published as part of a larger inquiry in the department of anthropology, and for years and years it has been prominent in that science, without, however, being applied to the corresponding phenomena of the life of animals and of plants. Only of late has it freed itself from its bounds, transgressed the old narrow limits, and displayed its prominent and universal importance as one of the fundamental laws of living nature.

In doing so, however, it has become the starting point for a critical review of the very basis of Darwin's conception of the part played by natural selection. It at once became clear that the phenomena which are ruled by this law, and which are bound to such narrow limits, can not be a basis for the explanation of the origin of species. It rules quantities and degrees of qualities, but not the qualities themselves.

Species, however, are not in the main distinguished from their allies by quantities, nor by degrees; the very qualities may differ. The higher animals and plants are not only taller and heavier than their long-forgotten unicellular forefathers; they surpass them in large numbers of special characters, which must have been acquired by their ancestors in the lapse of time. How such characters have been brought about is the real question with which the theory of evolution is concerned. Now if they can not be explained by the slow and gradual accumulation of individual variations, evidently the second alternative of Darwin's original proposition remains. This was based on the sports, on those rare and sudden changes which from time to time are seen to occur amongst cultivated plants, and which in these cases give rise to new strains. If such strains can be proved to offer a better analogy to real systematic species, and if the sudden changes can be shown to occur in nature as well as they are known to occur in the cultivated condition, then in truth Darwinism can afford to lose the individual variations as a basis. Then there will be two vast dominions of variability, sharply limited, and sharply contrasted with one another. One of them will be ruled by Quetelet's law of probability, and by the unavoidable and continuous occurrence of reversions. It will reign supreme in the sciences of anthropology and sociology. Outside of these, the other will become a new domain of investigation, and will ask to be designated by a new name. Fortunately, however, a real new designation is not required, since previous to Darwin's writings the same questions were largely discussed, and since in these discussions a distinct name for the sudden and accidental changes of species into one another was regularly used. At that time they were called 'mutations,' and the phenomenon of mutability was more or less clearly distinguished from that of variability in a more limited sense. Especially in France a serious scientific conflict raged on this point about the middle of the last century, and its near relation to religious questions secured it a large interest. Jordan and Godron were the leaders and numerous distinguished botanists and zoologists enrolled themselves under their banners. They cleared part of the way for Darwin and collected a large amount of valuable evidence. Their facts pleaded for the sharp and abrupt delimitation of their

species, and asked for another explanation than that which was derived from the ordinary, slow and continuous variations.

Their evidence, however, was not complete enough to command the decision in their behalf. The direct proof of the sudden changes could not be offered by them, and they allowed themselves to be driven to the acceptance of supernatural causes on this account. Thereby, however, they lost their influence upon the progress of science, and soon fell into oblivion.

Instead of following this historical line, however, I have now to point out one of the weightiest objections against the conception of the origin of species by means of slow and gradual changes. It is an objection which has been brought forward against Darwin from the very beginning, which has never relented, and which often has threatened to impair the whole theory of descent. It is the incompatibility of the results concerning the age of life on this earth, as propounded by physicists and astronomers, with the demand made by the theory of descent.

The deductions made by Lord Kelvin and others from the central heat of the earth, from the rate of the production of the calcareous deposits, from the increase of the amount of salt in the water of the seas, and from various other sources, indicate an age for the inhabitable surface of the earth of some millions of years only. The most probable estimates lie between twenty and forty millions of years. The evolutionists of the gradual line, however, had supposed many thousands of millions of years to be the smallest amount that would account for the whole range of evolution, from the very first beginning until the appearance of mankind.

This large discrepancy has always been a source of doubt and a weapon in the hands of the opponents of the evolutionary idea, and it is especially in this country that much good work has been done to overcome this difficulty. The theory of descent had to be remolded. On this point conviction has grown in America during the last decades with increasing rapidity. Cope's works stand prominent amongst all, and much valuable discussion and evidence has been brought together.

The decision, however, could only be gained by a direct study of the supposed mutations, but no distinct cases of mutability were at hand to provide the material. Discussions took the place of inquiry, and a vast amount of literature has broadly pictured all the possibilities and all the more or less plausible explanations without being able to give proof or disproof.

In this most discouraging state of things I concluded that the only way to get out of the prevailing confusion was to return to the method of direct experimental inquiry. Slow and gradual changes were accepted to be invisible or nearly so; mutations, however, would be clear and sharp, although of rare occurrence. I determined to start on a search for them, and tried a large number of species, partly native forms of my own country and partly from different sources. Each of them had to be tried as to its constancy, and large numbers of seedlings had to be produced and compared. The chance of finding what I wanted was of course very small, and consequently the number of the experiments had to be increased as far as possible.

Fortune has been propitious to me. It has brought into my garden a series of mutations of the same kind as those which are known to occur in horticulture, and moreover it has afforded me an instance of mutability such as would be supposed to occur in nature. The sudden changes, which until yet were limited to the experience of the breeders, proved to be accessible to direct experimental work. They can not yet in truth be produced artificially,

but, on the other hand, their occurrence can be predicted in some cases with enough probability to justify the trial. Color changes in flowers, double flowers, regular forms from labiate types, and others have been produced more or less at will in my garden, and under conditions which allowed of a close scientific study. The suddenness of the changes and the perfection of the display of the new characters from the very beginning were the most striking results.

These facts, however, only gave an experimental proof of phenomena which were historically known to occur in horticulture. They threw light upon the way in which cultivated plants usually produce new forms, but between them and the real origin of species in nature the old gap evidently remained.

This gap, however, had to be filled out. Darwin's theory had concluded with an analogy, and this analogy had to be replaced by direct observation.

Success has attended my efforts even on this point. It has brought into my hands a species which has been taken in the very act of producing new forms. This species has now been observed in its wild locality during eighteen years, and it has steadily continued to repeat the phenomenon. I have brought it into my garden, and here, under my very eyes, the production of new species has been going on, rather increasing in rate than diminishing. At once it rendered superfluous all considerations and all more or less fantastical explanations, replacing them by simple fact. It opened the way for further investigations, giving nearly certainty of a future discovery of analogous processes. Whether it is *the* type of the production of species in nature or only *one* of a more or less large group of types can not yet be decided, but this is of no importance in the present state of the subject. The fact is that it has become possible to see species originate, and that this origin is sudden and obeys distinct laws.

The species which yielded these important results is an American plant. It is a native of the United States, and nearly allied to some of the most common and most beautiful among the wild flowering plants of this country. It is an evening primrose, and by a strange but fortunate coincidence bears the name of the great French founder of the theory of evolution. It is called 'Lamarck's evening primrose,' and produces crowns of large and bright yellow flowers, which have even secured it a place amongst our beloved garden plants.

The most interesting result which the observation and culture of this plant have brought to light is a fact which is in direct opposition to the current belief. Ordinarily it is assumed that new species arise by a series of changes in which all the individuals of a locality are equally concerned. The whole group is supposed to be modified in a distinct direction by the agency of the environmental forces. All individuals from time to time intercross, and are thereby assumed to keep equal pace in the line of modification, no single one being allowed to go distinctly ahead of the others. The whole family gradually changes, and the consequence would be that the old form disappears in the same degree as the new makes its appearance.

This easy and plausible conception, however, is plainly contradicted by the new facts. There is neither a gradual modification nor a common change of all the individuals. On the contrary, the main group remains wholly unaffected by the production of new species. After eighteen years it is absolutely the same as at the beginning, and even the same as is found elsewhere in localities where no mutability has been observed. It neither disappears nor dies out,

nor is it ever diminished or changed in the slightest degree.

Moreover, according to the current conception, a changing species would commonly be modified into only one other form, or at best become split into two different types, separated from one another by flowering at different seasons, or by some other evident means of isolation. My evening primrose, however, produces in the same locality, and at the same time, from the same group of plants, quite a number of new forms, diverging from their prototype in different directions.

Thence we must conclude that new species are produced sideways by other forms, and that this change only affects the product, and not the producer. The same original form can in this way give birth to numerous others, and this single fact at once gives an explanation of all those cases in which species comprise numbers of subspecies, or genera large series of nearly allied forms. Numerous other distinct features of our prevailing classification may find on the same ground an easy and quite natural explanation.

To my mind, however, the real significance of the new facts is not to be found in the substitution of a new conception for the now prevailing ideas; it lies in the new ways which it opens for scientific research. The origin of species is no longer to be considered as something beyond our experience. It reaches within the limits of direct observation and experiment. Its only real difficulty is the rarity of its occurrence; but this, of course, may be overcome by persevering research. Mutability is manifestly an exceptional state of things if compared with the ordinary constancy. But it must occur in nature here and there, and probably even in our immediate vicinity. It has only to be sought for, and as soon as this is done on a sufficiently large scale the study of the origin of species will become an experimental science.

New lines of work and new prospects will then be opened, and the application of new discoveries and new laws on forage crops and industrial plants will largely reward the patience and perseverance required by the present initial scientific studies.

HUGO DE VRIES.

SCIENTIFIC BOOKS.

The Direction of Hair in Animals and Man. By WALTER KIDD, M.D., F.Z.S. London, Adam and Charles Black. 1903.

Dr. Kidd's recent work on the 'Direction of Hair in Animals and Man' is to a certain extent a compilation of his numerous previous works on the same general topic, to which is added a considerable amount of theoretical discussion. It is not intended to be an exhaustive treatment of the subject, but rather a discussion of those particular conditions which seem to substantiate the doctrines of Lamarck.

Three principles governing hair direction are pointed out:

1. That the simple and uniform hair slope of primitive mammals (*i. e.,* a general slope from cephalic toward caudal extremity of the body and from the proximal toward the distal end of the limbs) is not easily departed from in the individual development of any animal.

2. That there are certain modifications in this primitive arrangement that are due to morphological changes in the animal exhibiting them.

3. That all of the remaining phenomena of hair direction are to be explained by the action of mechanical forces on the surface of the body.

The first of these principles receives a brief discussion in which it is stated that the primitive hair slope corresponds to the direction of overlapping of the scales, which it is assumed covered the bodies of the earliest mammals. This law accounts for the slope of the major part of the hairy covering of any mammal. The existence of such a condition is

considered an adaptation and is attributed to natural selection.

The second law receives little explanation or discussion aside from a few illustrations.

It is upon the third law that the attention of the author is concentrated, since, obviously, the facts from which this law is deduced have direct bearing upon Lamarckism.

Those regions of the body of a mammal which are peculiarly open to contact with opposing surfaces or are under the special influence of certain active habits of a particular animal form are designated as 'critical areas.' They are the regions in which the action of the third law may be seen and they exhibit, to a greater or less extent, deviations from the primitive hair arrangement. Of such areas there are eleven, enumerated as follows: 'the naso-frontal, pectoral, cervical, axillary (post-humeral), inguinal, spinal, extensor surface of the ulna, ventral and lateral surfaces of the abdomen, extensor surface of the thigh, gluteal, and the side of the flank.' The deviations from the primitive hair slope which occur upon these areas are classified as (1) reversed areas of hair, (2) whorls, featherings and crests, (3) tufts.

A reversal involves a distinct opposition to the primitive hair direction and is attributed to the effect of contact with the ground or with other external opposing surfaces. Reversal is seen on the snout of the lion, for example, and over a still greater area on the nasal region of the horse and its allies. In these cases the hair, instead of sloping in the supposed primitive direction from the tip of the snout toward the top of the head, as illustrated by the red deer, slopes *toward the snout* from a point below the level of the eyes in the lion and between the eyes in the horse. This peculiarity of hair direction is explained as correlated with the angle at which the head is carried, and is attributed to the fact that air and other agents with which the face comes in contact oppose the primitive hair slope by stroking the hair toward the tip of the nose.

Most mammals spend a large proportion of their time in resting, and to the various positions employed much of the reversal of hair direction is due. This contact with the ground or with some portion of the body in the habitual sitting or recumbent position accounts for reversals upon: (1) the pectoral region of practically all mammals except ungulates, (2) the extensor surface of the ulna in carnivores, certain ungulates and primates, including man, (3) the lateral aspect of the abdomen in nearly all carnivores and ungulates, and (4) the extensor surface of the thigh in many species. As the reversed hair direction upon the extensor surface of the ulna in man has hitherto been considered an important vestigial character, this new explanation of it is of especial interest.

The second named deviation from the primitive hair direction, viz., the whorl, involves the divergence of hair from a point and may be accompanied by the phenomenon of a feathering. In those cases in which the feathering occurs two divergent hair streams lead from the whorl, curve on each side into the general hair direction of the region and often terminate sharply by a crest or ridge where the opposing hair stream is met. Whorls and their attendant phenomena are attributed by Kidd to 'strong, very frequent, divergent muscular action' in the region over which the whorl occurs; but, although he shows in numerous cases an extremely interesting correspondence between the location of the whorl, feathering and crest, and the divergent arrangement of the underlying muscles, he unfortunately omits to explain the mechanical process by which such divergent muscular action could affect hair direction. We naturally infer that the force exerted is applied to the hair follicle, but if this is the case, and it could hardly be otherwise, the effect of the pull would be to turn the external portion of the shaft, not in the same, but in the opposite direction. It is thus somewhat difficult to see how the action of divergent forces upon the follicles could result in the divergence of the external portions of the hairs, *i. e.*, in the formation of a whorl.

The most abundant illustrations of the whorl are drawn from the domestic horse, the highly developed locomotive habits of which render certain regions exceedingly subject to

very frequent, strong, opposing muscular tractions. In both the frontal and pectoral regions of the horse the whorl is said to be absolutely constant, and in the latter region it is accompanied by a feathering and crest, thus involving a reversal of the hair over a portion of the pectoral area. In other mammals, even those so closely related to the horse as the mule and ass, pectoral whorls are of much less frequent occurrence. The cervical, axillary and inguinal regions of the horse show whorls with a greater or less degree of constancy, and statistics indicate a correspondence between the development of locomotive power, on the one hand, and both the degree of perfection and the constancy of occurrence of these whorls, on the other, a correspondence the significance of which is of course emphasized by their infrequent occurrence in related forms of less highly developed locomotive power. Thus Kidd looks upon these whorls as actual 'pedometers,' and by way of emphasizing their significance draws a striking comparison between the horse and the zebra, which rarely exhibits any whorls. "These two animals carry about on their hairy coverings indubitable records of their habits and those of their near ancestors."

To the action of the *panniculus carnosus* of the back in shaking off flies and other insects are attributed the whorl and feathering which occur upon the spinal area of the lion, ox, giraffe and larger antelopes. Statistics are given to show the correlation of this phenomenon with a heavy mane and long tail, devices for removing insects from other regions.

In the gluteal region of some animals, particularly certain breeds of dogs, whorls are described which, contrary to the principles previously set forth in defining a whorl, are attributed to the *passive influence of external pressure* resulting from the frequently assumed sitting posture. In none of the cases which happen to have come under my own observation, however, does this feature involve a *divergence* of hair (the essential element of Kidd's whorl) the figure being distinctly a *convergent spiral* (in Voigt's terminology a 'convergierende Wirbel') corresponding more closely, as is shown later, to Kidd's definition of a tuft. Moreover, the sitting position of dogs is, so far as I have observed it, a crouching upon the hind legs, often with the ischial prominences hardly in contact with the ground, the weight being borne mainly upon the tarsus and foot.

Tufts, which of all the critical area phenomena are the most rare, involve always a convergence of the hair towards a point. Among the cases cited are those of the rare gluteal tuft of the horse said to be caused by the friction of the kicking-strap, and the more common gluteal tuft of the domestic ox, attributed to the habit of flicking the tail for the purpose of removing flies. There seems to be a decided discrepancy between these illustrations, with their explanations, and the general statement (p. 22) that tufts are the result of 'frequent, converging muscular action.' Even the tufts which are mentioned as occurring in the inguinal region in horses, although attributed to the action of the great oblique muscle, are not shown to be due to *convergent* muscular action.

These two regions, viz., the gluteal and inguinal, are the only ones upon which Kidd has found tufts. He has, however, overlooked several others of common occurrence, both on the horse and on other domestic animals. Such, for example, is the very common olecranal tuft which is well shown by short-haired dogs and is of practically constant occurrence in the human fetus.

A separate chapter is devoted to the consideration of the critical areas of man because man is the species the habits of which are the most completely known. Kidd finds *none of the peculiarities of hair direction in man dependent upon locomotive activity.* The numerous deviations from the primitive hair direction are, therefore, attributed not to motor phenomena, but rather to the influence of external forces.

The very ancient habit of sleeping or resting upon the back or side with the head and shoulders slightly elevated upon some sort of pillow is said to be responsible for many of man's peculiarities of hair direction. Among these are the partial reversal upon the deltoid

region and upon the lateral regions of the upper portion of the back, conditions found in no other species. These results are attributed to the tendency of the body to slide down from the pillow. The distinct lines of parting along the sides of the body on the ventral surface are thought to be possibly attributable to the pressure of the arm as it rests upon the body in sleeping, while the whorl which frequently occurs in this line is, contrary to the general principle earlier set forth as accounting for whorls, attributed to the pressure of the elbow.

The various methods of dressing the hair are said to account for the considerable variety of hair directions on the front of the scalp and the back of the neck.

The pressure of the clothing over the chest involved in respiratory movements is brought in to explain the reversal of hair above the 'sternal angle,' while the sudden diminution of hair at the level of the tops of the shoes is cited as an illustration of disuse and is attributed to the constant pressure of the shoe below that level.

In spite of the fact that the habits of man are so well known, it must be admitted that Kidd's discussion of the critical areas of man is the least complete and satisfactory portion of his book. Not only are some of the explanations submitted frankly given as mere conjectures, but many important phenomena are wholly ignored. For example, with the exception of the whorl upon the crown of the head, those which sometimes occur upon the lateral hair-parting of the trunk, and a pair in the pectoral region at the level of the sternal angle, there is no recognition of the many 'Wirbel' (Voigt's term) either divergent, *i. e.,* corresponding to Kidd's whorl, or convergent (Kidd's 'tufts') which have been so carefully worked out by Voigt and others and shown to be of such frequent, and in some regions of such constant occurrence upon the human body. Moreover, some of these phenomena correspond exactly in location to those to which Kidd attaches so much importance in his discussion of lower mammals. The axillary divergent Wirbel (a whorl), for example, has been found to be of practically constant occurrence in man. Kidd, in discussing the axillary whorl of the horse, says (p. 39) that in this region 'the more passive influences of pressure on the hair or friction are not represented, but it is an area with considerable opportunity for the active influence of strong, divergent muscular action to manifest itself.' He adds: 'Whorls in this region are so rare outside of the ungulate order that after an extensive search for it in other hair-clad mammals, I have been only able to find two instances in which it was present, and then only in a rudimentary form.' The cases cited are both dogs.

This statement and the fact that Kidd attributes none of the peculiarities of hair direction of man to motor phenomena, show that he was probably unaware of the existence of this, and possibly also of many other whorls and tufts upon the body of man. If aware of their occurrence, then there is a serious and very unfortunate discrepancy in his explanations, since these two phenomena are in the early part of the book distinctly attributed to divergent and convergent action, respectively, of underlying muscles.

After the discussion of critical areas in lower animals and in man, Kidd gives by way of summary a chapter on the 'Delimitation of Hair Tracts.' These hair tracts are shown to be either (1) primitive or (2) acquired, (*a*) by morphological changes or (*b*) by use or habit. The whole primitive hair slope is compared to the course of a river which continues unchanged until some obstacle interferes with its accustomed flow. These obstacles in the case of the hair stream are the mechanical forces which act upon the growing hair opposing the primitive direction of growth. If the action is sufficiently constant the course of the stream is changed. Thus the hairy coat of a mammal bears an indubitable record of the forces to which it has been exposed.

The otter is cited as a form in which the hair tracts are wholly primitive, while the ox, horse and especially man show that with increasing complexity of form and habits of life come increasing mechanical disturbance of the primitive condition and consequent

increasing complexity of hair slope. With reference to man the statement is made that man has 'acquired, by some means or other, and transmitted, a very remarkable series of changes both from the primitive and from the Simian type.'

Those hair tracts which have been acquired by 'morphological changes' are described as merging somewhat into those acquired through the effect of use or habit (*i. e.*, mechanical forces), 'the frontiers between the two being, of course, somewhat vague.' In fact, there is no criterion whatever given by means of which one may know which deviations from the primitive direction are due to these 'morphological changes,' the whole distinction being, so far as I have been able to determine, a purely arbitrary one.

Kidd's theoretical discussion involves the following line of argument:

Deviations from the primitive direction of hair can not, even in the case of long-haired forms (with the single possible exception of the extensor surface of the ulna of certain of the Anthropoidea) be considered an adaptation. These deviations can, therefore, have no selective value and can not, like the primitive direction, be accounted for by any process of selection, natural, sexual or germinal.

The correlation between the deviations from the primitive direction and the mechanical forces exerted upon certain areas of the body indicates that these deviations are due wholly to such forces. Deviation from the primitive direction is, however, not easily produced and occurs only when there is a decided preponderance of force in a single direction.

The existence of these deviations in fetuses and in the new-born indicates their inheritance. Hence in the realm of hair direction the Lamarckian principle of the inheritance of acquired characteristics is established.

Kidd claims for his views no opposition whatever to Darwinism. On the contrary, his course of reasoning seeks to establish a fusion between the two great principles of natural selection and use-inheritance. The issue is, however, distinctly with Weismannism, which claims the non-inheritance of acquired characters as an integral part of its theory.

It is obvious that Kidd has laid before us a large number of extremely interesting facts showing an indisputable correlation between the direction of hair and the mechanical pressure from various causes, exerted upon the skin. His explanation of this correlation can, however, hardly be accepted *as final* at the present stage of the investigation, and the following criticisms are offered merely as suggestive of further research which the field demands:

1. There is no recognition in Kidd's discussion of a possible difference between the direction of the external portion of the hair and that of the follicle. Before any of the variations in hair direction upon the human scalp can, for example, be logically attributed to methods of parting and dressing the hair, it should be shown that a change in the direction of the external, more or less wiry portion of the hair produces a change in the direction of the follicle. In the case of the sloth, also, it is unquestionably a fact that in obedience to gravitation the long hair hangs down, in the habitual inverted position of the body. It would be exceedingly interesting, and, for the validity of Kidd's argument, of absolute importance to know (1) whether the follicles themselves have this same direction and (2) whether this direction occurs in the fetus. No one, indeed, will deny the temporary action upon hair of gravitation or any other external force which may be applied to it; but to show that these forces acting upon the long external hair produce any real change in the direction of the growing portion of the hair, which alone constitutes hair direction as used morphologically, is a necessary link in the chain of reasoning which seeks to prove that congenital hair direction of an animal can be attributed to mechanical forces acting upon the external portion of the hair of its ancestors.

The failure to recognize the possible difference between the superficial condition and the real hair direction may be further illustrated by Kidd's treatment of the mole. He says: "The skin of this animal possesses that unusual quality of hair resembling velvet and has no fixed slope of hair, as is the case in

most other animals, for the simple reason, it may be presumed, of its burrowing habits." I have found, however, in my own study of moles that if the hair is cut close to the body there is displayed in every region a decided hair slope, showing much individual variation and many whorls, tufts and other phenomena such as Kidd elsewhere considers important. Plainly here there is no correspondence between the external or apparent condition and the true hair direction. An equally careful examination of each long-haired form should be made before any definite statement as to its hair direction is given, since it is possible that even an animal exhibiting superficially the so-called primitive hair slope might show in the direction of the follicles unsuspected deviations from this.

2. Although one of the data with which Kidd prefaces his discussion is 'that the direction of hair can be modified in the life of an individual animal,' he gives no account of the actual observation of such changes. He says, "This is obviously the case in the head and face of man and may be assumed to be so in lower animals though not easily shown in particular cases." If this datum be true, however, and if the hairy coat of a horse is so exact a 'pedometer' as Kidd believes it to be, it should be easily possible during the training of a colt for the race-course and its subsequent career to observe actual changes of hair direction, and his conclusions will carry greater weight when such observations have been made. Unfortunately the few unconscious experiments which are cited as having been performed by man are largely negative in their results.

3. With regard to the inheritance of peculiarities of hair direction, much light would probably be thrown upon the subject by the study of conditions in several successive generations. In the case of rapidly breeding animals (*e. g.*, white rats, which I have found show much variation in hair directions of certain regions) such observations might easily be made, and in many cases three generations, at least, of the human species would be available.

4. As already indicated, there is no explanation of the *process* by which the divergent traction of underlying muscles produces its supposed effect upon hair direction. The dynamic relation between such points of divergence and whorls is yet to be explained.

5. The very stronghold of Kidd's argument seems to be the assumed fact that practically none of the modifications of the primitive hair slope are adaptive. Is it not possible, however, that with a structure so complicated, so manifold in its functions, and, withal, at present so little known as the skin, even a short hairy covering may possess as yet imperfectly understood functions? Our present state of knowledge of this subject is, at least, not so complete that we are warranted in basing an argument upon the assumption of the lack of function of any particular hair direction.

Furthermore, even granting that a given hair direction is determined in response to mechanical causes, may not this very power of response on the part of the growing tissue be considered an adaptation and, therefore, of selective value?

On the other hand, ruling out any possibility of a selective process as accounting directly or indirectly for peculiarities of hair direction, Kidd fails to show any reason why these may not be simply spontaneous variations which, not held by a selective process to a definite course of evolution, are running riot, as it were. The very large amount of individual variation which Kidd himself acknowledges and which has been described by Voigt for the human species is itself an indication of the plausibility of such an explanation.

6. Kidd's treatment of the entire subject presents certain inconsistencies and discrepancies, some of which have already been pointed out. Probably the most serious of these is the lack of harmony between his preliminary statement of the cause of whorls and tufts as due to motor phenomena and his subsequent explanation of many of them as due to external pressure.

7. Perhaps the most serious fault of the whole work is the arbitrariness with which the lines are drawn distinguishing between the three principles governing hair direction.

With regard to the first of these, which assumes a primitive caudalward direction of the hair, it may be suggested that a careful study of the direction of the overlapping of scales not only in the few mammals in which these structures persist but in other scaly vertebrates, particularly reptiles, may show that the arrangement of scales upon which this primitive hair direction is based is not so simple a one as it is here assumed to be. My own investigation of this subject, the results of which I hope later to publish, has shown me that scale arrangement may involve points and lines both of convergence and of divergence.

With regard to the second principle, that of hair directions due to 'morphological changes,' I have already confessed an inability to understand what phenomena this principle accounts for or to determine upon what basis any particular modification of the 'primitive hair direction' would be ascribed to it. To be sure, the author says distinctly that he makes no attempt to discuss this principle. By omitting, however, to at least clearly define it he exposes himself to the criticism of having selected from the observed phenomena of hair direction those for which he could discover or conjecture a mechanical cause, and of having relegated to this nondescript class all other phenomena except those which are included under the supposed primitive direction.

It is, indeed, inconceivable that, provided mechanical forces can produce inheritable changes in hair direction, the hairy coat (or in fact, the scaly coat) of a mammal should at any stage of its evolution have been free from the influence of such mechanical forces. In other words, to explain a primitive hair direction as to any less extent due to the action of mechanical forces than are the deviations from it is illogical. Thus while Kidd's classification of hair tracts is a useful one for purposes of discussion, to base such a classification upon a distinct difference in cause (*i. e.*, natural selection, morphological change and use inheritance) is to employ arbitrary distinctions.

We are indebted to Dr. Kidd for reviving an especially fine field, not so much for theoretical discussion as for scientific research which should eventually yield many data for such discussion. What is particularly needed at present is not a selection of facts to prove Lamarckism, Darwinism, Weismannism or any other theory, but a laborious, careful, complete working out of the entire field of hair directions, in as many forms as possible, together with a study of scale arrangement and the relation of scales to hair, to determine, if possible, the primitive conditions. Science has no place for dogmatic statement, and no hypothesis, however satisfactory when considered in view of one set of facts, should be protected at the sacrifice of a knowledge of any other facts which research may bring to light. Every scientist will argue with Dr. Kidd that 'the scientific attitude is that of judging a large series of facts on their own merits, and according to the weight of evidence, even if it tend against a widely accepted hypothesis!'

INEZ L. WHIPPLE.
SMITH COLLEGE, NORTHAMPTON, MASS.
August 1, 1904.

DISCUSSION AND CORRESPONDENCE.

ON CITING THE TYPES OF NEW GENERA.

IT seems worth while to call attention to the desirability of formally transferring the species upon which new genera are based, when these species have been earlier described in other genera. It seems a very trifling matter, but a bibliographer has to cite what he finds in print, and that only; and as a result of the present practise of many zoologists, the actual combination of a new generic name with its type species often occurs, not at the place where the genus is proposed, but accidentally, as it were, in some other easily overlooked place. To illustrate my meaning, I may refer to a couple of very recent instances:

Gilbertella, Eigenmann, Smiths. Misc. Coll., Vol. 45, p. 147. (1903.)
"*Type.—Anacyrtus alatus*, Steind."

Dimmockia, Ashmead, Mem. Carnegie Mus., Vol. 1, p. 357. (1904.)
"*Type.—Eulophus incongruus*, Ashm."

It seems to me that the proper way would have been to write for the first, type, *Gilbertella alata* (*Anacyrtus alatus*, Steind.), and the

second, type, *Dimmockia incongrua* (*Eulophus incongruus*, Ashm.).

T. D. A. Cockerell.

VARIÆ AUCTORITATIS.

To the Editor of Science: The early authorities alluded to by Mr. Eastman are always of interest and more so than modern men seem disposed to admit, hence it is of genuine value to run down his reference to 'Origines.'

In the first place, it should be obvious that the form 'Origines' could not come from *Origen*, as Mr. Eastman suggests.

It seems likely that Mr. Emmons, or *his* author, intended to quote the 'Origines' of M. Porcius Cato (Cato Major), who died B. C. 149; and of which work in two books fragments remain.

I have not the work by me, but believe there is something of the kind quoted from it in a medieval Latin writer, Lullius, if my memory serves me right, or it may have been Albertus Magnus, a work of whose is bound up with an early edition of a treatise by Lully.

The study of the early writers, difficult as it is from lack of knowledge of the meanings of their technical terms, is most unwarrantably neglected; and for the same reason their attainments are ignorantly sneered at. The old idea that Galen thought the arteries carried air, repeated from text-book to text-book, is a case in point, easily disproved by any one with a knowledge of ancient phraseology, from Galen's writings.

Much ancient tradition thus passes out of our ken, to be dug out by the solitary explorer here and there, but to vanish for ages or longer from the sum of practical human knowledge.

Geo. Chas. Buchanan.

Mora, Minn.,
August 17, 1904.

SPECIAL ARTICLES.

INTRUSIVE BURIALS IN ANCIENT MOUNDS.

The custom, which was formerly practised by various tribes throughout the Mississippi valley, namely, that of utilizing the ancient mounds as places of burial for their dead, is even now followed by some Ojibways in Minnesota. The Ojibway village of Sa-ga-wah-mick, which is located on the south shore of Mille Lac in the state of Minnesota, is situated in the midst of a group of some sixty mounds —many of these being seven or eight feet in height. According to the Ojibway tradition, which is also verified by historical facts, the country adjacent to Mille Lac was formerly occupied by the M'de Wakan Sioux who were driven out by the Ojibways about the year 1750, or, according to the Ojibway's story, 'five generations ago.'

The Indians at Sa-ga-wah-mick recognize the mounds as being artificial, and claim they were erected by the Sioux over the remains of their dead. Several facts tend to justify the belief that such may be the true explanation of their origin. Fragments of pottery which I found near the original surface in a mound about four feet in height were similar in structure and design to pieces which were discovered upon the surface of a village site, near by, and which is known to have been the site of a Sioux settlement before the country was occupied by the Ojibways. The peculiar form of burial discovered in the mounds was certainly entirely different from any known to have been practised by the Ojibways and would conform with the Sioux habit of removing the flesh from the bones before the latter were interred. In one mound which I opened were four burials. The arm and leg bones of each skeleton had been bunched separately, upon each was placed a skull, all rested upon the original surface and the mound of earth had been formed over them. In addition to these only one small bone was found in the mound.

The Ojibway believing these mounds to have been erected by the Sioux, now utilize them as burial places for their own dead.

On the sides and top of one of the largest mounds at Sa-ga-wah-mick were counted thirteen comparatively recent graves, all having the box-like cover of hewn logs—so typical of Ojibway burials—upon one end of which was cut the totem of the deceased. Around the summits of several mounds a picket fence had been erected to surround and thereby protect the graves.

Thus we find in a remote Ojibway village

the survival of a custom which was once practised throughout the Valley of the Mississippi—that of utilizing the ancient mounds as places of burial.

In many mounds which have been examined in the central and southern section of the valley, interments have been discovered only two or three feet below the present surface of the mounds. A notable instance of this sort occurred at the time of the destruction of the large mound which formerly stood in the city of St. Louis. In 1869 when the mound was removed, human remains were found about three feet below the surface near the north end.* Stone graves were also found upon the summit of the same mound, a group of five having been examined by members of the Long Expedition as early as 1819.†

According to a statement made by Conant, the large mound must have been used by the Indians as a place of burial, as late as 1819 or the same year it was seen and described by the Long party.

"This mound, as is well known, was used by the Indians as a burial place, and only about sixty years since, it was visited by a small band, who disinterred and carried away the bones of their chief, who had been buried there."‡

At a meeting of the Ethnological Society in January, 1861, E. G. Squier described a burial which had recently been discoverd near the summit of a small mound near Cahokia, opposite St. Louis, and stated "that the position of the skeleton in the mound would lead him to infer that it was of comparatively recent deposit. His experience was that the true remains of the mound builders were generally to be found at the bottom of the mound, immediately under its apex."

Such a conclusion would apply to the mounds at Mille Lac; the 'true remains of the mound builders' are found at the bottom of the mound on the original surface, while the secondary or intrusive burials are made by the Ojibways. D. I. Bushnell, Jr.

Cambridge, Mass.,
July 22, 1904.

* Conant, 'Footprints of Vanished Races,' 1879, p. 41.

† 'Expedition from Pittsburg to the Rocky Mountains,' Phila., 1823, Vol. I., p. 64.

‡ Conant, p. 41.

§ *Bulletin of the Ethnological Society*, Vol. I., p. 25, January, 1861.

CURRENT NOTES ON METEOROLOGY.

A WORLD-WIDE BAROMETRIC SEE-SAW.

To *Nature* for June 23, Dr. W. J. S. Lockyer contributes an article under the above title, in which the results of recent studies by Sir Norman Lockyer and himself are embodied. Two pressure variation types were selected, that over India and that at Cordoba, and the pressure curves of other places were compared with these two type curves. When any pressure curve extending over several years showed an excess pressure at those epochs when the Indian pressure curve was in excess, it was classified as similar to the Indian type, and represented by a +. If more like the Indian curve than the Cordoba curve, but not quite the exact counterpart of India, it was marked + ?. Similarly, pressure curves like Cordoba were classified as —, and those more like Cordoba than India, as — ?. Other cases, difficult to classify satisfactorily, were marked ± ? or ?. The signs of the different types of pressure variation were then entered on a map of the world, and the two main regions were separated by neutral lines. It is interesting to note that the two neutral lines are fairly symmetrical to one another. Both lines apparently cross the equator at antipodal points, and both appear to have a similar trend in north and south latitudes. The indication is that a general law exists with regard to pressure changes which occur simultaneously in these two extensive regions of the globe, the neutral lines forming a fulcrum about which see-saws of pressure from one region to another take place. Professor Bigelow, of the U. S. Weather Bureau, has reached conclusions along the same line of investigation which are in the main similar to those here discussed. The importance of these studies is in connection with the possible long-range forecasting of the future, for it is probable that regions which are the reverse of one another as regards secular pressure variations should have opposite kinds of abnormal weath-

er, while those over which the same type of pressure variation exists should have weather of an abnormal but similar nature.

VERTICAL TEMPERATURE DECREASE UP TO 10 KILOMETERS.

A PAPER on the vertical decrease of temperature up to altitudes of 10 kilometers, as determined by balloon observations, was read by Hann before the Vienna Academy of Sciences on April 21, 1904. The object of the investigation, the results of which were presented in this report, was to ascertain whether the annual march of the temperature at great altitudes in the free air can at present be determined with fair accuracy on the basis of the observations already made during balloon ascents. The data employed were obtained on 150 ascents up to seven kilometers, and on 125 up to heights between seven and ten kilometers. Among the most interesting of Hann's results are those which concern the rate of decrease of temperature vertically in cyclones and anticyclones in winter and summer. These agree with Hann's conclusions based on the Sonnblick observations up to three kilometers, and with the results obtained by de Bort for greater altitudes. The vertical decrease of temperature in the lower air is slower in anticyclones than in cyclones, but at greater altitudes the relations change. The lowest temperatures at great heights are found in anticyclones. In the lower air, and above eight kilometers, the minima are warmer, and in the intermediate strata the maxima are warmer. The excess of temperature in the anticyclones reaches at its maximum about 9° in the stratum between two and three kilometers. Similar differences were previously found from the Sonnblick observations. The general mean between one kilometer and ten kilometers gives an excess of temperature for the anticyclonic air, but definite conclusions must be postponed until the publication of de Bort's results.

WEST INDIAN HURRICANES.

As usual during the tropical cyclone season, the 'Pilot Chart of the North Atlantic' for July contains an account of West Indian Hurricanes, by James Page (reprinted from Hydrographic Office Publication No. 86, Gulf of Mexico and Caribbean Sea, Vol. I., 5th edition, 1901). This is an excellent brief account of the most important facts regarding season and frequency; origin and development; area and depth; direction of the wind and bearing of the storm center; distance of the center; weather changes during the approach of a tropical cyclone; the motion of the storm center and the shifts of the wind; and maneuvering. Four figures show: (I.) the generalized track and the direction of the inflowing winds; (II.) tracks of the more important hurricanes during the ten-year period 1890–1899; (III.) barometric pressure and wind at Havana during the hurricane of October 19, 1876; and (IV.) positions in which vessels caught in a hurricane should 'lie to.' Extra copies of this discussion on West Indian hurricanes may be obtained on application to the hydrographer, Navy Department, Washington. The August 'North Pacific Ocean Pilot Chart' has a similar discussion of typhoons.

CLIMATE OF EGYPT.

THE 'Meteorological Report for the Year 1901,' published by the Survey Department, Public Works Ministry, Cairo, has recently been received (Cairo, 1903). The usual international tables are given for seven stations in Egypt and six in the Sudan, including Omdurman, Wadi Halfa and Suakin. In a personal letter to the compiler of these notes, Captain H. G. Lyons, director-general of the Survey Department of Egypt, writes as follows: "I have this time published large diagrams of the daily observations, and it is interesting to see the prompt effect of a Mediterranean depression passing near our African coasts. I hope that a note on the Khamsin winds will be published this year. These are not a special spring effect, as has frequently been said, but are our southerly winds which we may have at any time, though their intensity and sand-carrying power is greatest in May."

R. DEC. WARD.

HARVARD UNIVERSITY.

THE NATIONAL ANTARCTIC EXPEDITION.*

It is anticipated that the National Antarctic Expedition may reach these shores one day during next week. Since its departure in August, 1901, the expedition has passed two years and two months within the Antarctic Circle, and has achieved results which admittedly place it in the very first rank of Polar expeditions. The return of the *Discovery* will complete another entry in the long roll of exploring enterprises for which, as well as for her warlike victories, the British navy has so long been distinguished. Much of the success of the expedition is due to the rare gifts for command displayed by Commander Robert Scott amid the trying conditions of life in the Antarctic; but the officers and men also deserve warm praise for their devoted loyalty and zeal. All alike have done splendid work, and all alike have earned the thanks of their countrymen.

The task assigned to Commander Scott and his companions in the official instructions was one which in any case was bound to make large demands on the courage and skill of all concerned. To spend one winter in the far south would have been no mean achievement. But the expedition has done more than this. Circumstances necessitated the passing of a second winter in the Antarctic; and the work of the second winter and the second traveling season, while doubling the results, has more than doubled their scientific value. The expedition involved hardships of no ordinary kind, perils on which the members of the expedition will be the last to dwell, difficulties which only Polar men can appreciate; but the reward has been great. Extensive geographical discoveries have been made, and accurate surveys completed. These are certainly worthy of all the attention they have attracted, but they form only a part of the achievement. The discovery of a fossil flora in the far south is of itself an event of great scientific importance. The biological collections are unique; for they are the only collections that have been made 700 miles to the south of the Antarctic Circle. The careful meteorological records are greatly enhanced in value by their extension over a couple of years. The magnetic observations recorded at sea, as well as those registered on the Antarctic land, will certainly be of very special interest. Those taken with the Eschenagen instruments form a continuous record comprising 700 magnetograms. It is of course premature to anticipate final results, though there are several fascinating problems awaiting solution; but it may be mentioned that when, on November 1, 1903, a magnetic storm prevailed from Potsdam to New Zealand, the magnetic disturbances observed at the *Discovery's* winter quarters were unusually numerous and violent. The value of the observations for declination, inclination and total force during the memorable journey over the great ice barrier, when a record southing was attained, is very great, because the observations were secured under conditions quite free from local disturbances. The results will, therefore, be specially useful in fixing the position of the magnetic pole. Other branches of physical work, such as the taking of observations in connection with the force of gravity, seismic disturbances and atmospheric electricity, were steadily pursued throughout both years.

The *Discovery* is now approaching our shores with this rich harvest of scientific results. Letters have been received from members of the expedition from the Falkland Islands, dated the third week in July. On the whole, good weather had been enjoyed throughout the voyage from New Zealand, and it was anticipated that the *Discovery* would reach England about September 15; but a telegram from Ponta Delgada, which was printed in *The Times* yesterday, indicates that she will arrive much sooner, probably 'about the 10th.' It is seldom in these days that an opportunity is afforded of welcoming home an expedition which has accomplished such brilliant and extensive explorations. Every effort will be made to give all the members of the expedition a fitting reception. On the arrival of the *Discovery* at the London docks it is proposed to entertain officers and men at a luncheon, which it is hoped the Lord Mayor will be able to attend, as well as representatives of the

* From the London *Times*. It is announced by cable that the *Discovery* has duly arrived.

Admirality, the Royal and Royal Geographical Societies and other public bodies. On the following day the Royal Geographical Society will give a dinner to the officers and scientific staff. According to present arrangements, officers and men will then be allowed to rest in peace, so far as public functions of an official character are concerned, until the beginning of November, when it is hoped that Commander Scott will open the new session of the Royal Geographical Society with a summary account of the whole expedition. This will be a special meeting, and possibly will be held in the Albert-hall.

THE CROCKER ECLIPSE EXPEDITION OF THE LICK OBSERVATORY.

Mr. William H. Crocker has offered to meet the expenses of observations on the total solar eclipse of August 30, 1905. Three expeditions will be sent out from the Lick Observatory to Labrador, Spain and Egypt. The provisional program for the three stations is as follows:

Labrador: A photographic search for intramercurial planets in a region of the sky $8\frac{1}{2}°$ wide, extending in the direction of the solar equator from 4° below the sun to 15° above it. The photography of the corona by means of a camera of five inches aperture and forty feet focus, of the form first used by Professor Schaeberle at the eclipse of 1893.

Spain: A photographic intramercurial search covering a region $9\frac{1}{4}°$ wide, extending in the direction of the solar equator from 14° below to 14° above the sun. The photography of the solar corona with a camera of five inches aperture and forty feet focus. A study of the polarized light in the corona. The use of spectrographs provided with moving plate-holders to obtain a continuous record of changes in the spectrum of the sun's edge at the time of second and third contacts; of spectrographs for determining the wave-length of the green coronal bright line, and, if possible, the wave-lengths of the bright and dark lines in the isolated spectrum of the sun's edge, as nearly as possible at the time when the dark lines give way to bright ones, and *vice versa;* and of a spectrograph for recording the general spectrum of the corona.

Egypt: A photographic intramercurial search $8\frac{1}{2}°$, extending in the direction of the solar equator from 4° below to 15° above the sun. The photography of the solar corona with a camera of five inches aperture and forty feet focus. The photography of the general spectrum of the corona.

SCIENTIFIC NOTES AND NEWS.

Dr. G. K. Gilbert, of the U. S. Geological Survey, has been elected a foreign member of the Accademia dei Lineei, Rome.

Commander R. E. Peary was presented with the gold medal of the French Geographical Society by its president, M. Cordier, at the banquet of the International Geographical Congress given in New York on September 14. In accepting the medal Commander Peary announced his plans for Arctic exploration next year.

Dr. Philipp Lenard, professor of physics at Kiel, and Dr. Adolf de Koenen, professor of geology, at Göttingen, have been elected foreign members of the Belgian Academy of Sciences.

Captain R. S. Scott, of the *Discovery,* has been promoted to the rank of a captain in the Royal Navy.

The council of the British Institution of Civil Engineers has, in addition to the medals and prizes given for communications discussed at the meetings of the institution in the last session, made the following awards in respect of other papers dealt with in 1903–1904: Telford premiums to Arthur Hill, C.I.E. (Bombay), F. A. Hurley (Cairo), E. M. De Burgh (Greystones), H. H. Dare, M.E. (Sydney, N. S. W.), William Marriott (Melton Constable), T. G. Gribble (London), W. H. Haigh (Cardiff). For students' papers the awards are: A Miller scholarship, tenable for three years, and the James Forrest medal to C. W. L. Alexander, B.E. (Birmingham); Miller prizes to J. M. Clark, M.A., B.Sc. (Glasgow), L. G. Crawford (Barrow-in-Furness), W. H. Dickenson, B.Sc. (Jesmond-on-Tyne), William Lawson (Newcastle-on-Tyne), C. G. Du Cane, B.A. (Middlesbrough), C.

Gribble (York), J. E. Lister (Sheffield), J. M. Kennedy (London), H. Middleton (Newcastle-on-Tyne), J. D. Morgan (Handsworth).

Mr. Samuel Henshaw, A.M., of Cambridge, Mass., has been appointed curator of the Museum of Comparative Zoology, at Harvard University. He is the third curator in succession of that museum. Professor Louis Agassiz, the founder, was curator, then director from 1859 until his death; in 1873 he was succeeded by his son, Dr. Alexander Agassiz, who resigned in 1898. Since that date Dr. W. McM. Woodworth has been assistant in charge, then keeper. Mr. Henshaw was connected with the Boston Society of Natural History as assistant from 1876 to 1892, and as secretary and librarian, 1892–1899. He succeeded the late Professor H. A. Hazen as assistant in entomology in the Museum of Comparative Zoology, in 1892 and was appointed librarian in 1899. These two positions he has since held.

The president of the British Institution of Civil Engineers, Sir William White, and more than one hundred members of the institution, have arrived on the Cunard steamship, *Etruria*, on a visit to the United States and Canada. The invitation to the institution to pay this visit, the first of the kind made since its foundation in 1818, was given by the American and Canadian Societies of Civil Engineers. It is proposed to take part also in the International Engineering Congress organized in connection with the St. Louis Exhibition, to be held in October.

Dr. and Mrs. N. L. Britton sailed for Nassau, New Providence, on August 19, for the purpose of continuing the exploration of the Bahamas.

Mr. Malcolm Playfair Anderson, of Stanford University, left for Japan early in July to carry on biological work under the auspices of the Zoological Society of London. He will make collections of mammals and birds and other specimens of the island fauna and flora, and a general rough survey of the natural history features.

Dr. Ernst A. Bessey, of the United States Department of Agriculture, who has been abroad for somewhat more than two years, will return about the first of October. While abroad he traveled in Russia, the Caucasus, Turkestan and Algeria, for the Department of Agriculture. He spent some time in study in the Universities of Halle and Munich, finishing his work for the doctorate in Halle last spring.

During the past summer Professor C. N. Gould, of the University of Oklahoma, assisted by E. G. Woodruff, conducted investigations on the subject of water supply in the Panhandle of Texas for the United States Geological Survey. Professor Gould last year made a reconnaissance along the Cimarron and South Canadian Rivers in Oklahoma, Texas, Kansas, Colorado and New Mexico, and on the completion of the field studies submitted a report on the geology and water resources of Oklahoma. A similar report on the water resources of the Panhandle will be submitted during the coming winter.

Dr. W. A. Murrill has been appointed assistant curator, at the New York Botanical Garden, in the place of Professor F. S. Earle, who resigned to become director of the Experiment Station of Cuba.

Mr. R. M. Arango has been appointed a consulting engineer on the staff of Chief Engineer Wallace in the Panama Canal construction.

Dr. Alexander C. Abbott, chief of the Bureau of Health, and professor of hygiene in the University of Pennsylvania, delivered the inaugural address at McGill University, on September 12.

Dr. J. Deniker, librarian of the Paris Museum of Natural History, will deliver the Fifth Huxley Memorial Lecture of the Anthropological Institute of Great Britain and Ireland, on October 7. He will take as his subject 'The Races of Europe.'

Dr. C. L. Herrick, editor of the *Journal of Comparative Neurology and Psychology*, died at Socorro, New Mexico, on September 15. Stricken with pulmonary tuberculosis early in 1894, he left his professorship in Denison University and succeeded for more than ten years in holding his disease in check in the climate of the far south-west. This period of

exile, though filled with suffering and privation, was one of the most productive of his life. During four of these years as president of the Territorial University of New Mexico he did valiant service for the cause of higher education in the southwest, and during the whole time was conducting and publishing researches in zoology and geology, besides supporting his family by practising as a mining expert. During the last few months of his life failing physical strength gave opportunity for a final formulation of much unfinished work, particularly in philosophical lines, a part of which has already been published, and much of which is still in manuscript.

Professor Ed. von Martens, vice-director of the Berlin Zoological Museum, died on August 14, at the age of seventy-three years.

We also regret to record the death of Dr. P. van der Vliet, formerly professor of physics at the University of St. Petersburg, aged sixty-four years.

King Edward has directed that a new medal be struck for service in polar regions. The officers and crew of the Antarctic exploration ship *Discovery* will be the first recipients of the medal.

The U. S. Civil Service Commission will hold an examination on October 12, for the position of assistant to the agrostologist, of the Bureau of Plant Industry, Department of Agriculture, with a salary of $1,400 a year. On the same day an examination will be held for the position of assistant preparator in the Division of Vertebrate Paleontology, National Museum, at a salary of $480 a year.

In a recent number of the *Bulletin* of Lick Observatory, Professor W. W. Campbell states that the late Director Keeler's observing program for the Crossley reflector included the photography of about one hundred of the principal nebulæ and star clusters. The portions of this program available for observation in clear summer weather were practically complete at the time of his death; but those in position during the cloudy winter months, forming nearly a half of the whole, were incomplete. After the lamented death of Professor Keeler, Assistant Astronomer Perrine, in charge of the Crossley reflector, made it his first duty to complete the observing program. This was accomplished in September, 1903. The importance of prompt publication of this invaluable series of photographs has been fully realized, but difficulties, both technical and financial, have existed. Owing to the generosity of friends of the Lick Observatory plans have recently been completed, whereby it is hoped to issue, within the coming half-year, a volume of the *Lick Observatory Publications*, to contain high-class reproductions of seventy-two of the principal subjects, as well as a list of several hundred new nebulæ incidentally recorded on the negatives.

The University of Chicago paleontological expedition to Wyoming the past summer has obtained a valuable and extensive collection of land reptiles from the Trias. The material collected includes labyrinthodonts, dinosaurs, anomodonts and phytosaurs of several kinds. One specimen, largely complete, apparently belonging in the last group, has a slender, teleosaur-like skull nearly three feet in length, armed with serrated, cutting, dinosaur-like teeth. Several labyrinthodont skulls of at least two forms were obtained. The material will be described as soon as possible by Dr. S. W. Williston and Mr. E. B. Branson, of the University of Chicago.

The International Geographic Congress and the Society of Chemical Industry have been holding their meetings and making the visits in accordance with the programs to which we have already called attention. We hope to publish later some account of the proceedings.

The International Astronomical Congress began its meetings at Lund on September 5.

The second International Congress of Philosophy was opened at the university at Geneva on September 4, with 316 members in attendance.

The fifteenth annual general meeting of the British Institution of Mining Engineers was held at Birmingham on September 14.

The fourth Congress of the International Aeronauts' Committee, with about 60 members in attendance, met at St. Petersburg, beginning on August 30.

The International Conference for Wireless Telegraphy, summoned at the initiative of Germany, which was to have met October 4, has been postponed at the request of France and Great Britain, these countries desiring more time to study the questions involved.

A Reuter telegram from Basel, dated August 30, states: "The second International Congress on the History of Religions was opened at 11 o'clock this morning. Professor von Orelli, of Basel, president of the organizing committee, in opening the first plenary sitting, welcomed the delegates, and speeches were also made by Professor Raville, representing the Swiss Federal Council, and Professor Burckhardt, representing the Cantonal government, and by members of various learned societies. The speakers included Dr. Hauptmann, of Baltimore, on behalf of the United States government, and Mr. H. M. A. Balfour, on behalf of Oxford University. Professor von Orelli then read an address in the course of which he pointed out that the objects of the conference were purely scientific, and that a propaganda in favor of a particular sect and controversies on the lines of religious discussions during the middle ages would not be allowed. Over 300 savants from all parts of the world have already arrived. The conference will be divided into eight sections, seven of which will deal with the religions of the following peoples and countries respectively: (1) Primitive Races, including the Peruvians and Mexicans; (2) the Chinese and Japanese; (3) the Egyptians; (4) the Jews; (5) India and Persia; (6) the Greeks and Romans; and (7) the Germanic, Celtic, Slavonic and Hungarian Races. The eighth section will devote itself to the discussion of the Christian Religion."

We learn from *Nature* that it is proposed to fix a standard time for use upon all Indian railways and telegraphs, which shall be exactly five and one half hours in advance of Greenwich time, and to fix for Burma a standard six and one half hours in advance of Greenwich. The government of India has intimated that it is in favor of the adoption of the new standard for general as well as for railway and telegraphic purposes, and is prepared to cooperate in any movement with this end in view; but as the matter is one upon which the local communities should be consulted, the opinions of the chambers of commerce upon the proposals are being sought by the government.

We learn through the London *Times* that the annual report for 1903 of the Swiss National Museum at Zürich, recently published, contains an account of a donation to that institution by Dr. H. Angst, C.M.G., the founder, for all practical purposes, of the museum, and its first director. At the end of last year, Dr. Angst resigned the directorship, but accepted a position as representative of the Canton of Zürich on the museum commission. Before his retirement, however, had actually taken place, but when it had been already decided on, Dr. Angst crowned his life's work for the museum by presenting to the institution at once, substantially the whole of his great and almost unique collection of Swiss antiquities, including glass and pottery. Even before the museum was opened, Dr. Angst had made over to it a very valuable collection, representing some £4,000 sterling; and soon after, fearing that in a private house they might be exposed to danger, he entrusted to the institution as a loan the rest of his collection, embracing antiquities of all sorts, in the purchase of which not less than £20,000 had been actually expended, while with the rise in market prices, the present value is much greater. This property Dr. Angst has now conveyed, in immediate and complete possession, to the museum without waiting for his death, one half of it—that is £10,000 value—as an unconditional gift, and the other half in consideration of a payment in cash of £2,000 and of a moderate life-rent to cover the balance. This act was gratefully recognized by the Swiss government in an official letter signed by the president and the chancellor of the Confederation, and by the rising of the members of the National Council in their seats when the donation was publicly announced.

The new metallurgical smelting-house at Bournbrook in connection with Birmingham University was formally opened on Sep-

tember 5. In an introductory lecture at the university Professor Turner said, according to the London *Times,* that the beginning of the work marked an important event in the history of the section. The erection of the building had occupied a year and entailed an expenditure of not much less than £10,000. There was no more ready index of the progress of civilization in any nation than that afforded by the knowledge of the work and value of its metallurgical products, and it was of the utmost importance that metallurgical industries should be encouraged and developed if Great Britain were to keep her position amongst the nations of the world. With regard to the position of the United Kingdom in metallurgical industries, a great change had been witnessed in the last twenty-five years. England used to be spoken of as the chief coal and iron producer of the world, and also occupied a prominent position as a producer of other metals. It still led in gold because of the Transvaal and Australia, but was now second in coal, third in iron, fifth or sixth in other metals, and only produced about one twentieth part of the tin, lead and zinc which were made in the world. The two chief competitors had been the United States and Germany, and the reasons for their progress were varied. In America there were the necessities of a new country, the rapid development of their railways, the opening up of enormous fields of ore deposits and coal fields. There was also the question on which the chancellor of the university had spoken a great deal, the question of tariffs; but he was more immediately interested at the present moment in the influence of education on metallurgical progress and the lines that should be followed in connection with that subject. Professor Turner went on to enumerate the schools of metallurgy in America and Germany, and to show that some of them were on a scale that had hitherto not been matched in Great Britain.

UNIVERSITY AND EDUCATIONAL NEWS.

By the will of the late Dr. Henry Tuck, Harvard University will receive one fourth of the estate should his children not survive. The estate is valued at $5,000,000.

Ground was broken for the new Eastman building of Rochester University, to be used for biology and physics, for which Mr. Eastman, of Rochester, gave $60,000. The effort to raise necessary funds towards the $150,000 required for the building has been successful. Of the desired amount, the sum of $120,000 is in hand, including $15,000 contributed by Hiram W. Sibley for the renovation and decoration of the library.

The following assistants have been appointed at Leland Stanford Junior University: *Mechanical Engineering,* R. H. Gaither; *Education,* E. R. Snyder, Miss C. F. Atherton; *Entomology,* Miss M. I. McCracken; *Zoology,* W. K. Fisher, H. M. Spaulding; *Physics,* C. K. Studley, Miss G. N. Brown; *Physiology,* J. F. Cowan, M. Sindo; *Chemistry,* W. E. Crawford, C. C. James, N. E. Dole, R. H. Sherry, Miss J. A. Comings, D. F. Fitzgerald, W. E. Burke; *Civil Engineering,* J. F. Byxbee, T. B. Hunter, Jr., E. G. Brua, L. J. Mayreis, G. A. Hodge.

C. G. Rogers, assistant in physiology in the University of California, has been appointed instructor in physiology at the University of Kansas.

Mr. Alexander Lauder, senior demonstrator in chemistry in the University College of North Wales, Bangor, has been appointed lecturer in agricultural chemistry in the Edinburgh and East Scotland College of Agriculture.

Dr. Oskar Hertwig, professor of comparative anatomy, at Berlin, has been appointed rector of the University.

Professor E. Wichert, of Göttingen, has been called to a chair of physics at Königsberg; Professor Eduard Brückner, of Bern, has been called to a professorship of geography, at Halle.

Professor O. E. Meyer, director of the Physical Laboratory, at Breslau, will retire from active service at the close of the present semester.